3. ЕЛЕКТРОПОКРЕТАЧИ-СТАРТЕРИ

РАЗВОЈ СТАРТЕРА

- 1886. – Karl Benc – патентирао моторно возило са бензинским мотором;
- 1888. – Berta Benc – прво путовање у историји аутомобилизма;
- 1910. – уведен је први оловни акумулатор;
- 1913. – први електрични стартер фирмр Bosch;
- 1950. – аутомат са електичним релејом;
- 1980. – стартери са сталним магнетима;
- 1982. – стартери са међупреносником.

ЕЛЕКТРИЧНЕ МАШИНЕ НА ВОЗИЛИМА

РАЗВОЈ СТАРТЕРА

2 Flywheel starter motor with manual engagement mechanism

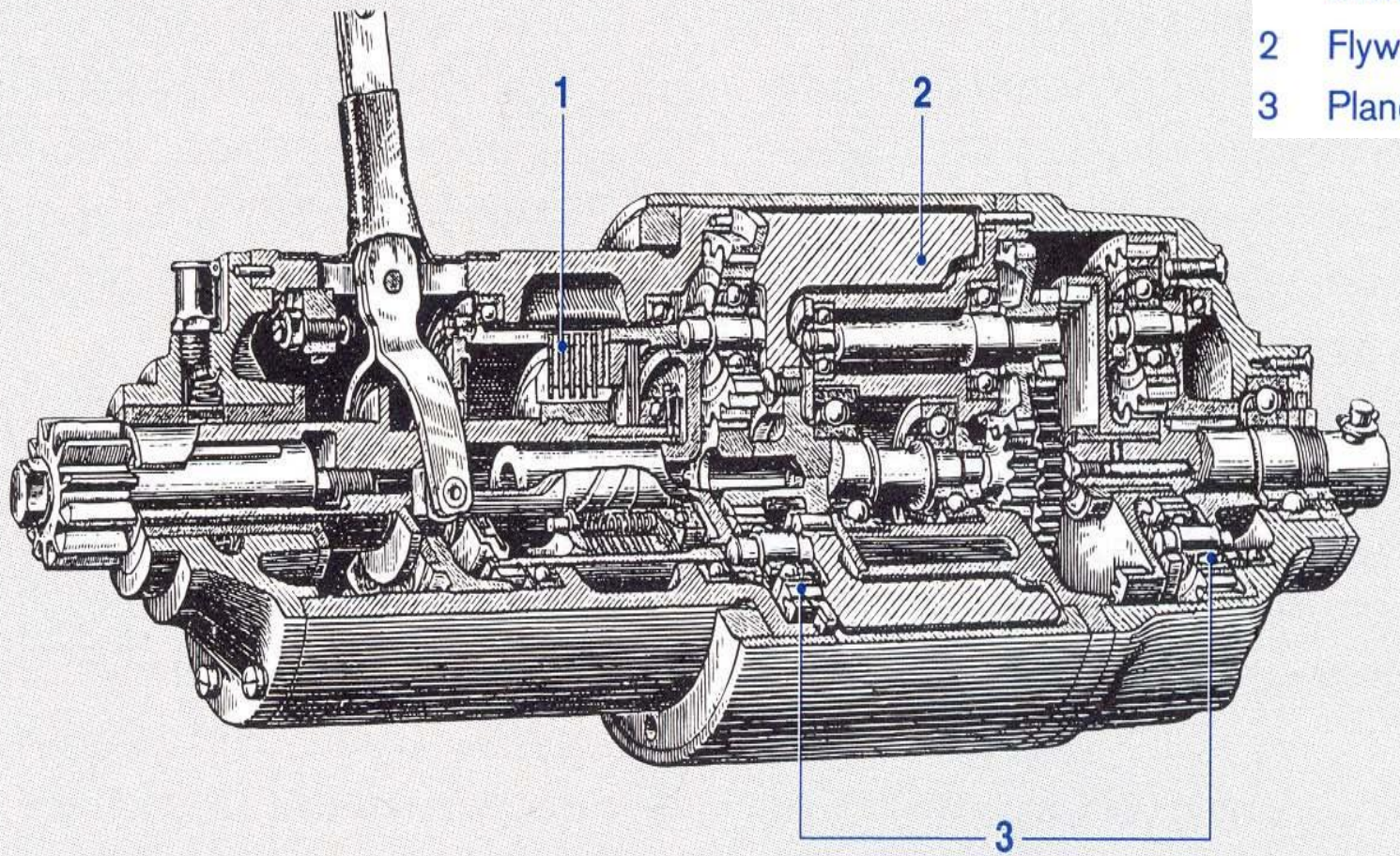


Fig. 2
1 Multiplate overrunning clutch
2 Flywheel
3 Planetary gear

ЕЛЕКТРИЧНЕ МАШИНЕ НА ВОЗИЛИМА

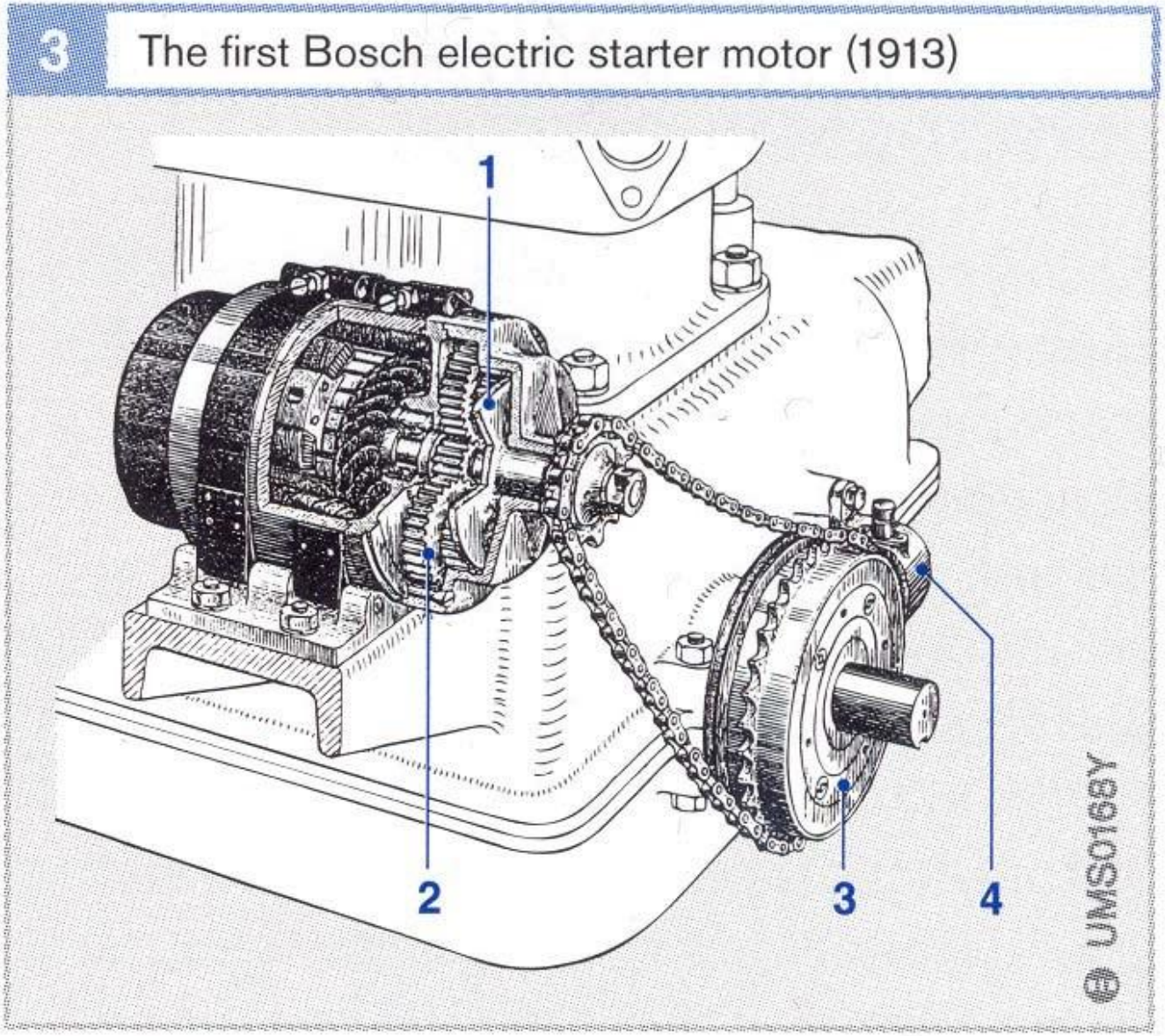
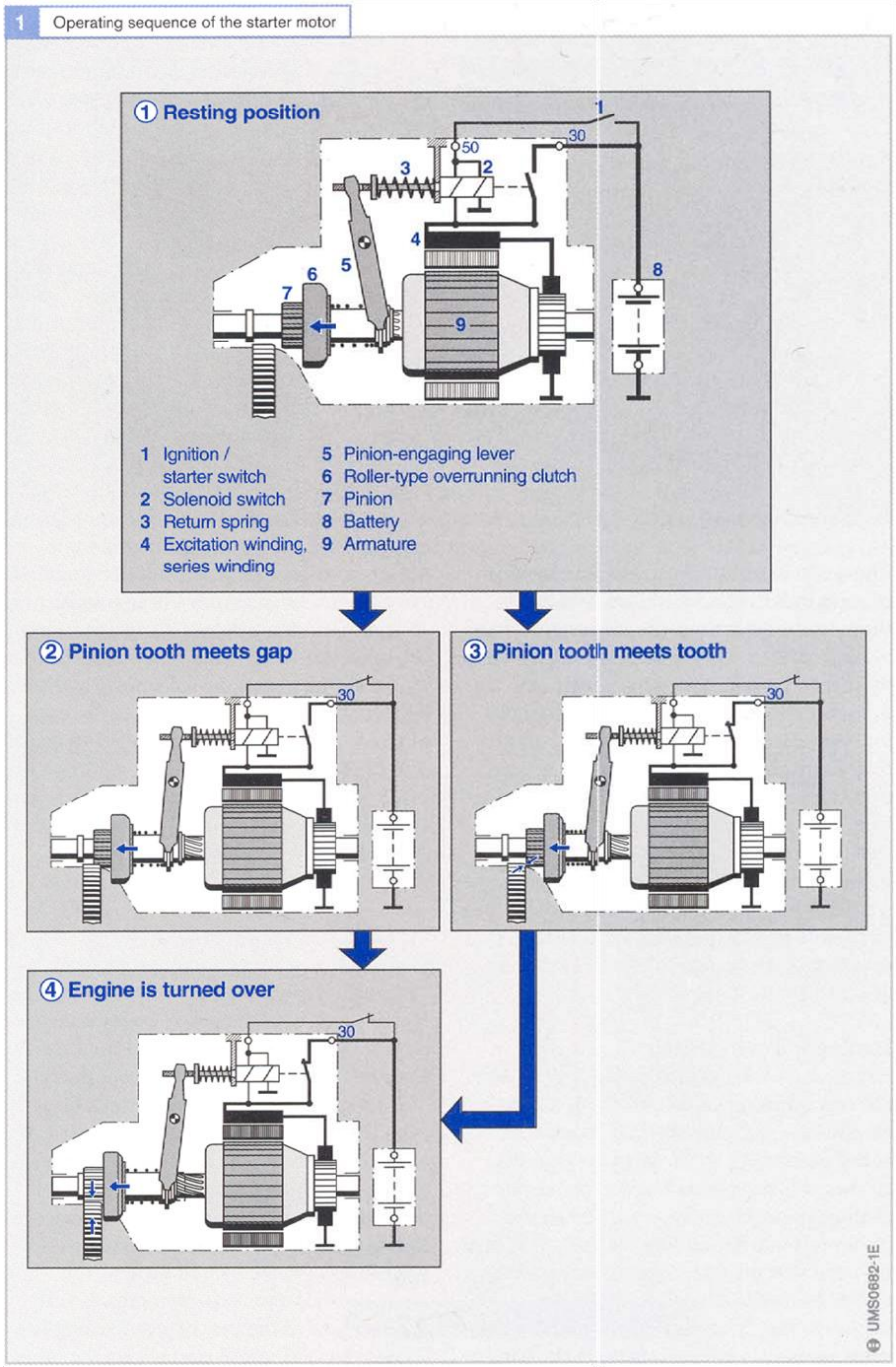


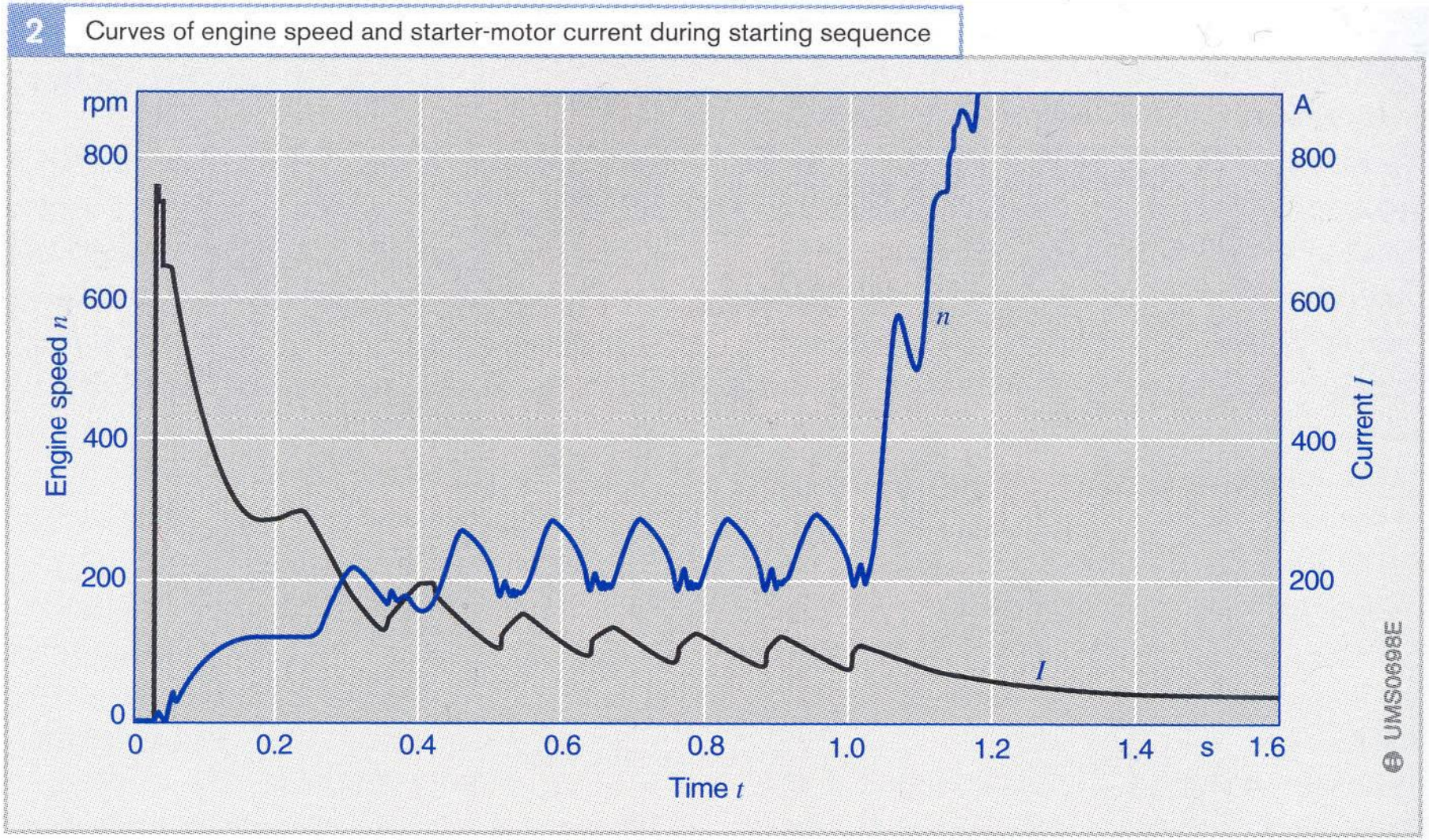
Fig. 3

1 Starter motor
2 Planetary gear
3 Freewheel
4 Magnetic brake

Фазе рада стартера



СТАРТОВАЊЕ МОТОРА СУС



ЕЛЕКТРИЧНЕ МАШИНЕ НА ВОЗИЛИМА

Фазе рада стартера

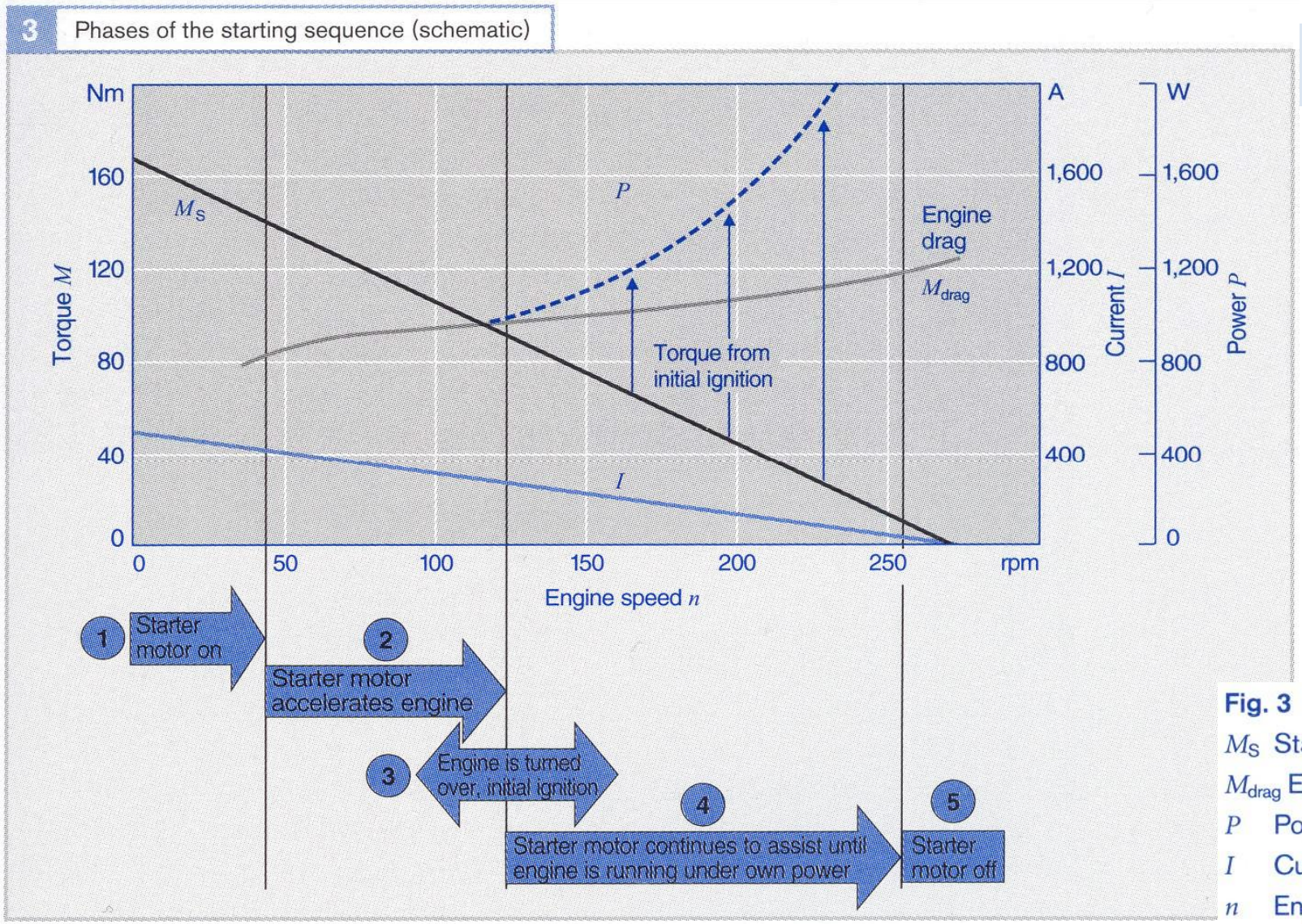


Fig. 3

M_S Starter-motor torque
M_{drag} Engine drag
P Power
I Current
n Engine speed

Температурна зависност момената

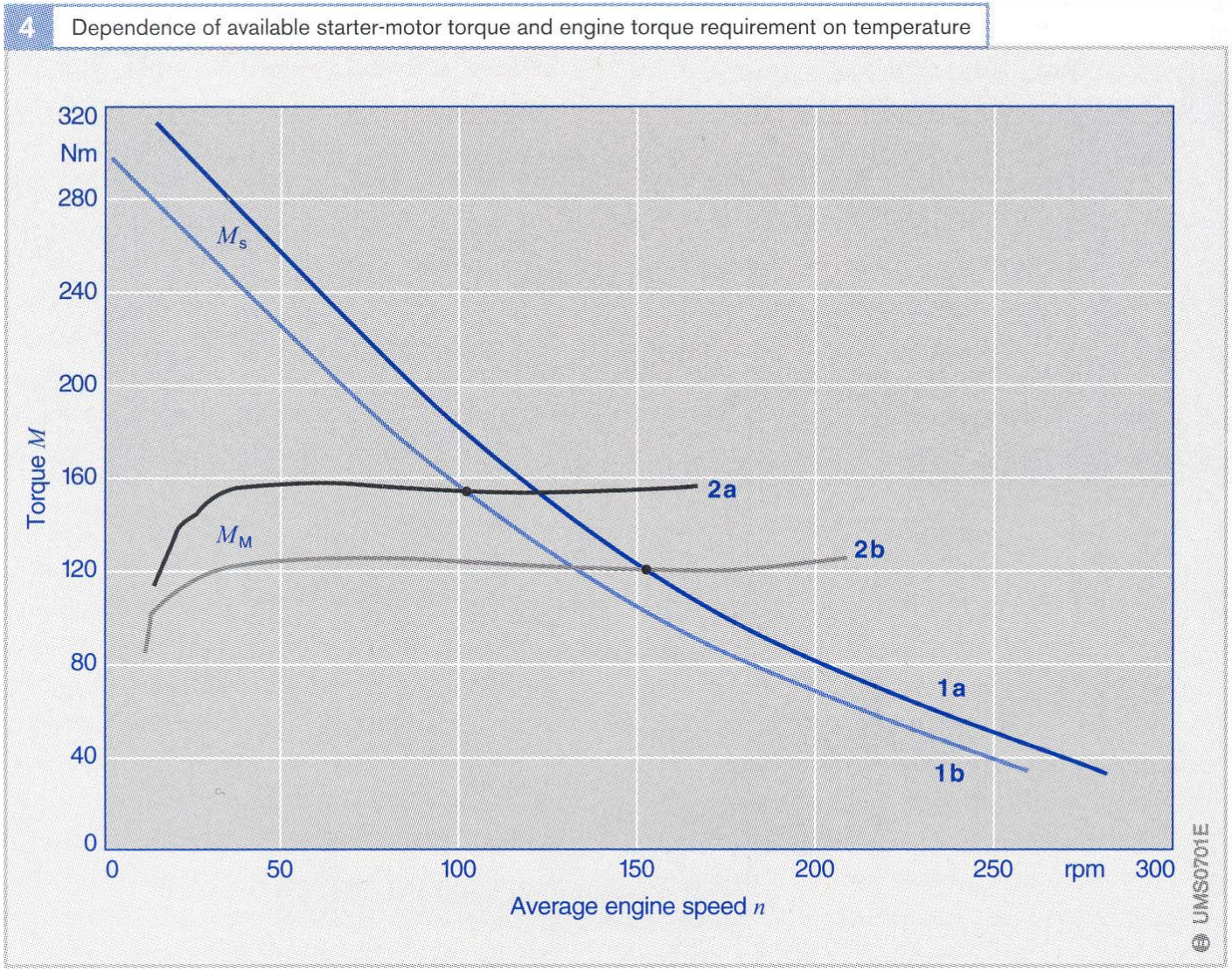


Fig. 4

1 Starter-motor torque M_S (available torque) measure using battery with rating of 64 Ah 380 A, P_E 20 %

1a At −20 °C
$U_0 = 10.9$ V
$R_i = 4.5$ mΩ
$R_{zul} = 1.3$ mΩ

1b At −24 °C
$U_0 = 10.6$ V
$R_i = 5.6$ mΩ
$R_{zul} = 1.3$ mΩ

2 Engine drag M_M (torque requirement)

2a At −24 °C, engine oil SAE10W40

2b At −20 °C, engine oil SAE10W40

Гранична температура стартовања

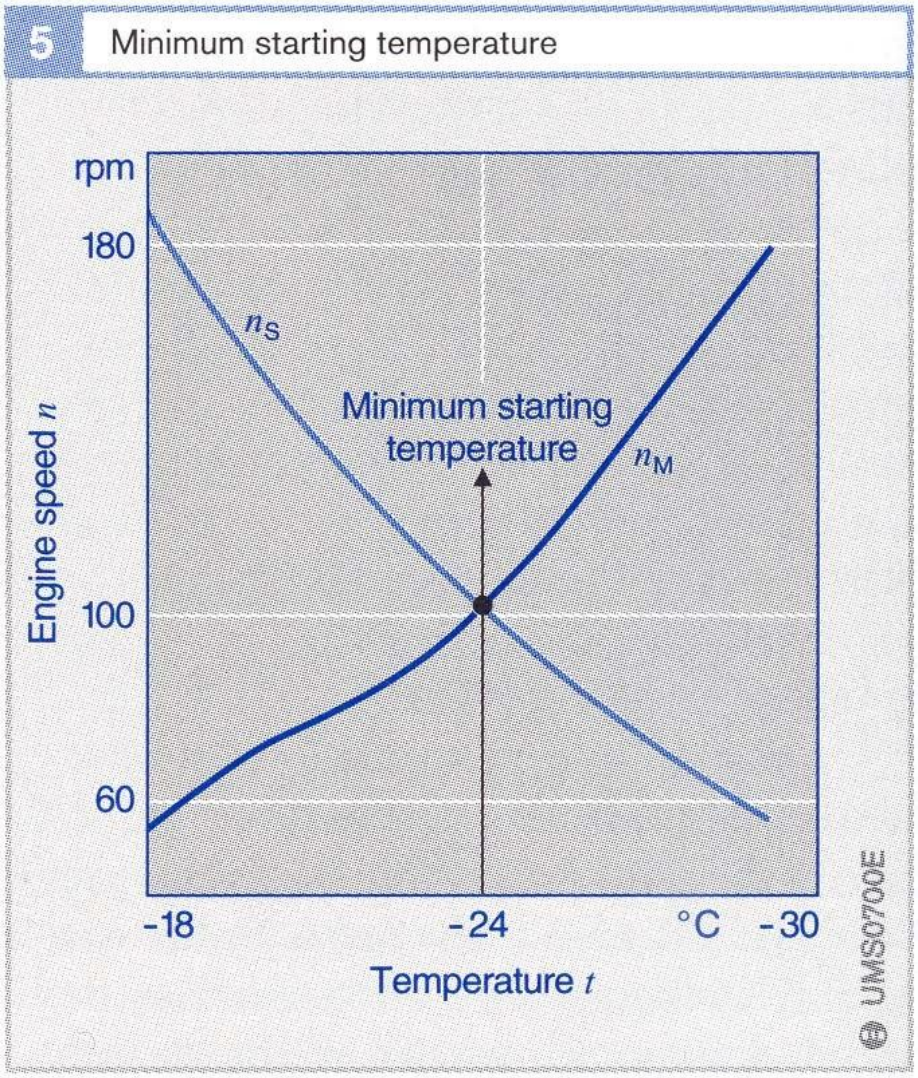


Fig. 5

t_G Minimum starting temperature

n_S Engine speed achieved by starting system

n_M Minimum speed required for starting

ЕЛЕКТРИЧНЕ МАШИНЕ НА ВОЗИЛИМА

1 Minimum starting temperatures

Type of engine	Minimum starting temperature °C
Car engines	–18...–28
Truck/bus engines	–15...–32
Tractor engines	–12...–15
Marine and power-generator engines	–5
Engines for diesel locomotives	+5

2 Typical minimum starting speeds at –20 °C

Engine type	Speed rpm
Gasoline engine	60...100
Direct-injection diesel engine without start-assist systems	80...200
Direct-injection diesel engine with start-assist systems	60...120

КОНСТРУКЦИЈА СТАРТЕРА

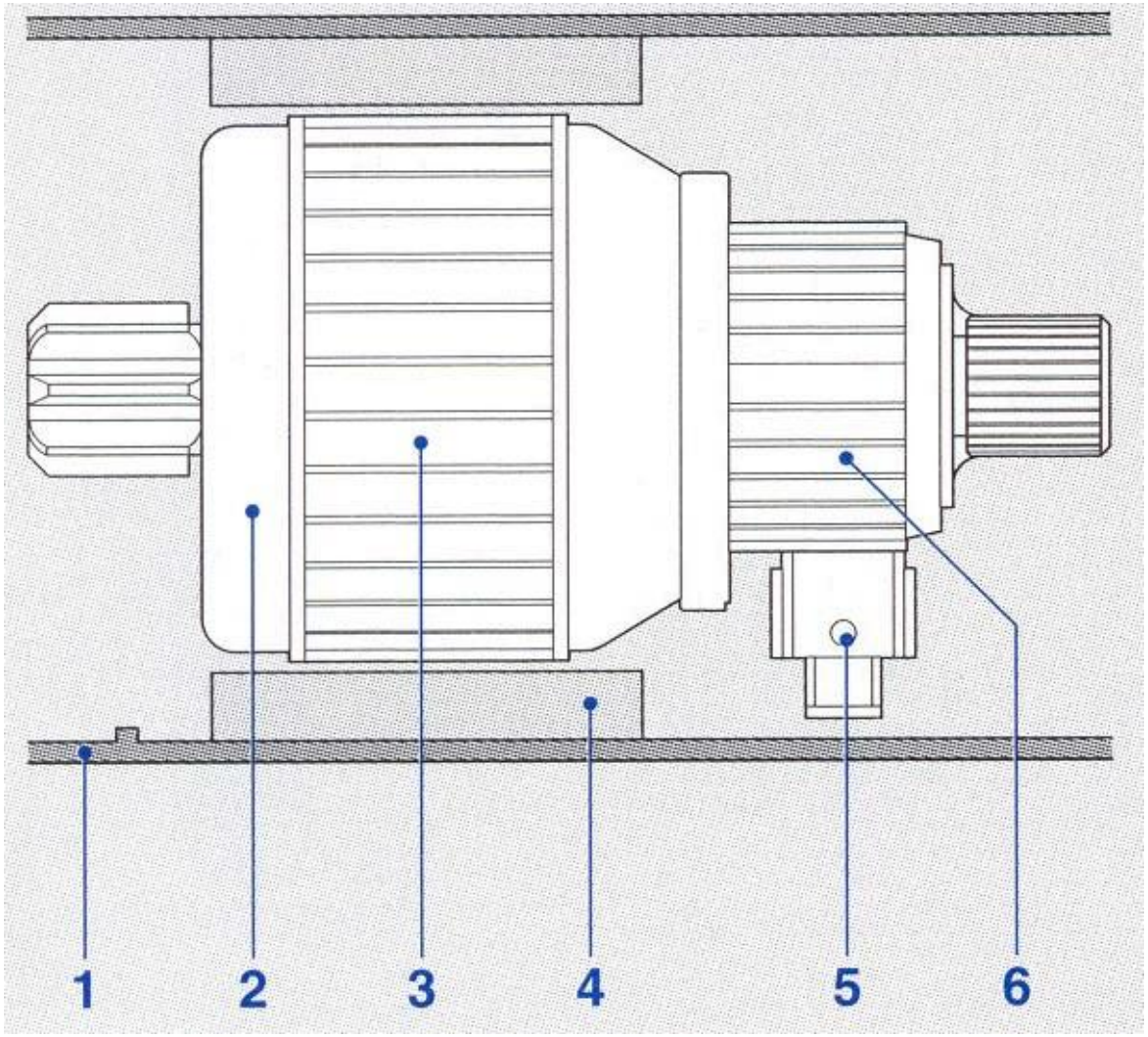


Fig. 1

1 Stator housing
2 Armature winding
3 Laminated core
4 Permanent magnets
5 Carbon brushes
6 Commutator

ЕЛЕКТРИЧНЕ МАШИНЕ НА ВОЗИЛИМА

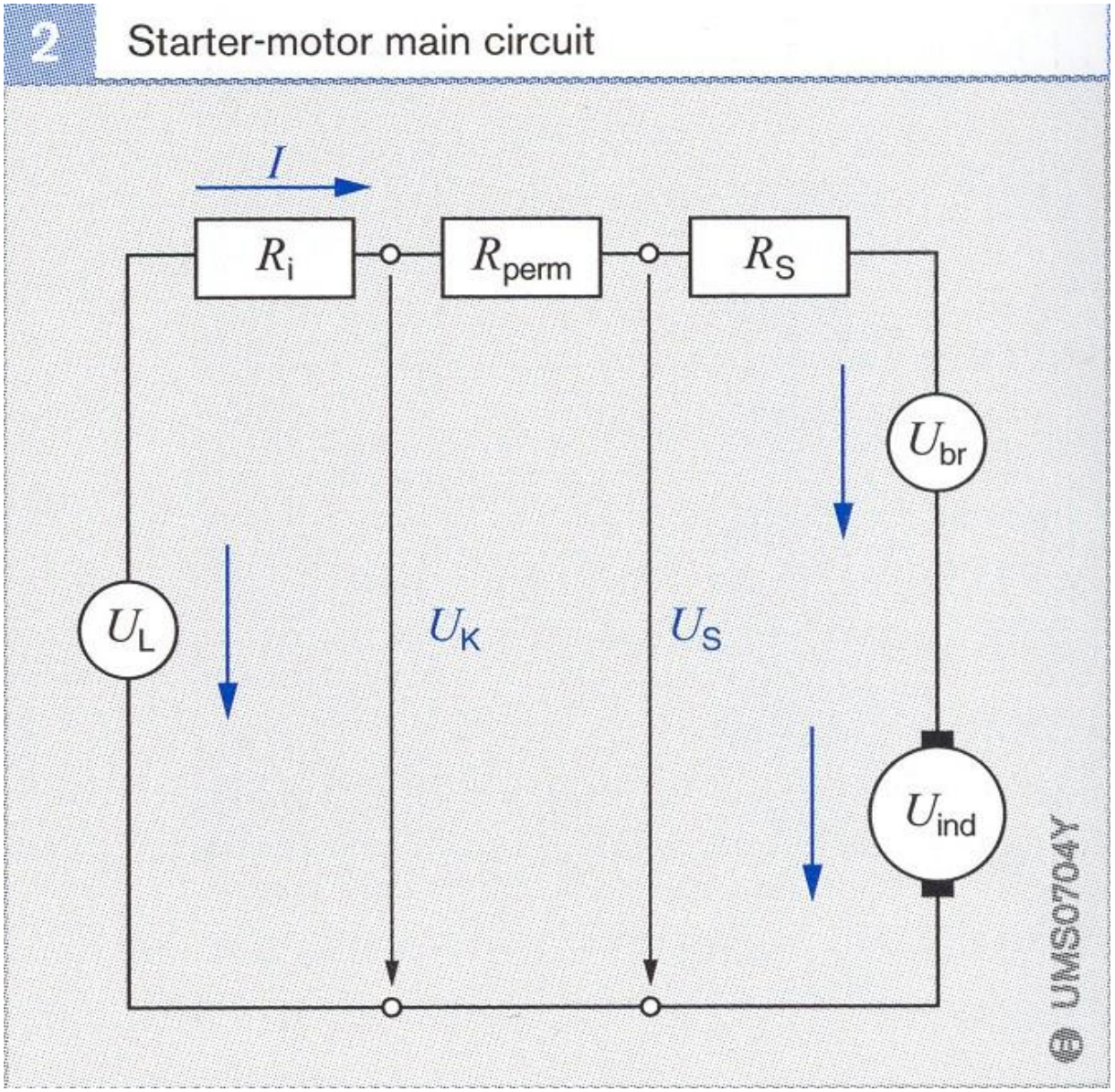


Fig. 2

R_i Internal impedance of battery

R_S Starter-motor impedance

R_{perm} Power-cable impedance

U_L No-load voltage of battery

U_K Battery-terminal voltage

U_S Starter-motor voltage

U_{br} Voltage drop across brushes

U_{ind} Induced voltage in armature winding

Обртни момент и снага стартера

$$M = c_1 \cdot B \cdot l_{Fe} \cdot d \cdot I, \qquad \text{Eq. 1}$$

$$U_{ind} = 2 \cdot \pi \cdot c_2 \cdot B \cdot l_{Fe} \cdot d \cdot n,$$

$$U_L = (R_i + R_{perm} + R_S) \cdot I + U_{br} + U_{ind}$$

$$U_L = (R_i + R_{perm} + R_S) \cdot I + U_{br} + 2 \cdot \pi \cdot c_2 \cdot B \cdot l_{Fe} \cdot d \cdot n,$$

$$n = \frac{U_L - U_{br} - (R_i + R_{perm} + R_S) \cdot I}{2 \cdot \pi \cdot c_2 \cdot B \cdot l_{Fe} \cdot d} \qquad \text{Eq. 2}$$

Обртни момент и снага стартера

$$P_i = 2 \cdot \pi \cdot M \cdot n$$

$$= \frac{c_1}{c_2} \left[(U_L - U_{br}) \cdot I - (R_i + R_{perm} + R_S) \cdot I^2 \right]$$

Eq. 3

$$(R_i + R_{perm} + R_S) \cdot I^2 .$$

$$P_m = P_i - V_R - V_{Fe}$$

ВРСТЕ ПОБУДЕ

Побуда од сталних магнета

3 Stator housing with permanent magnets

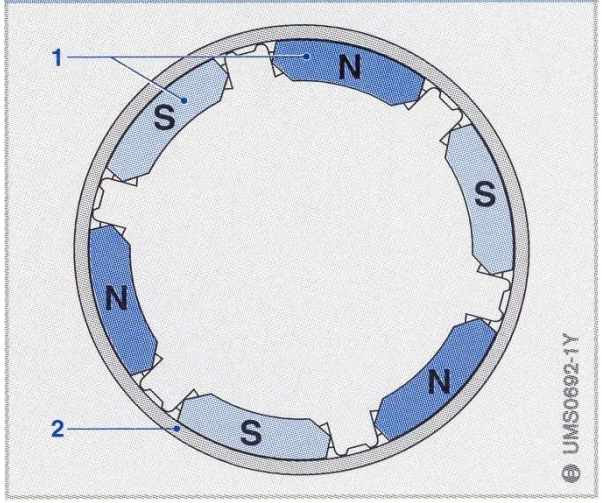
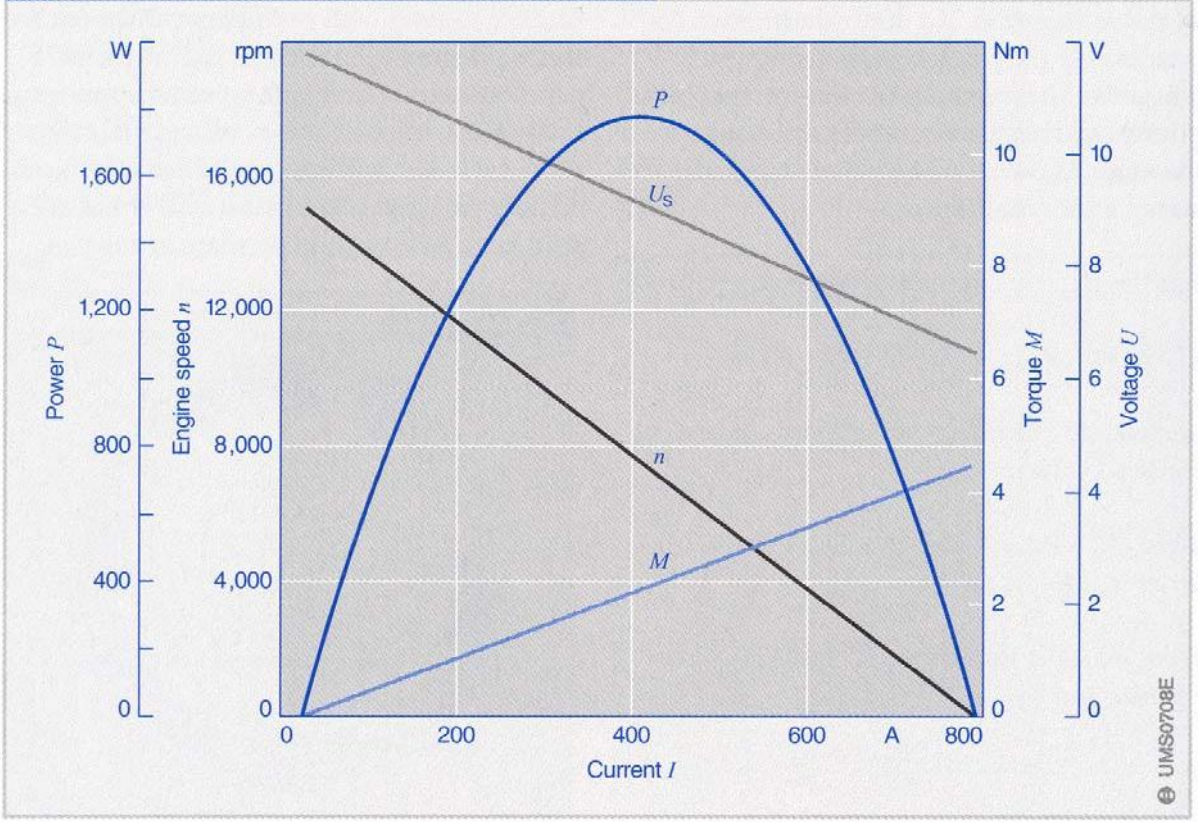


Fig. 3

1 Permanent magnets

2 Stator housing

4 Characteristics of permanent-magnet DC motor (schematic)



Редна побуда

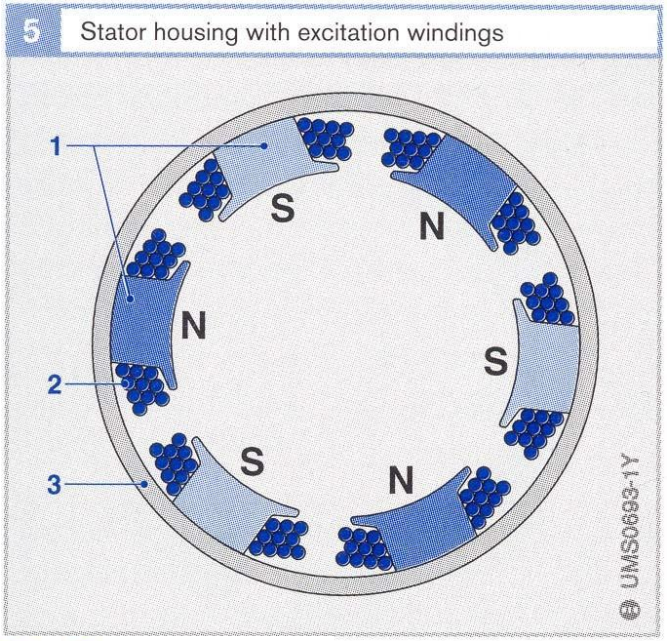
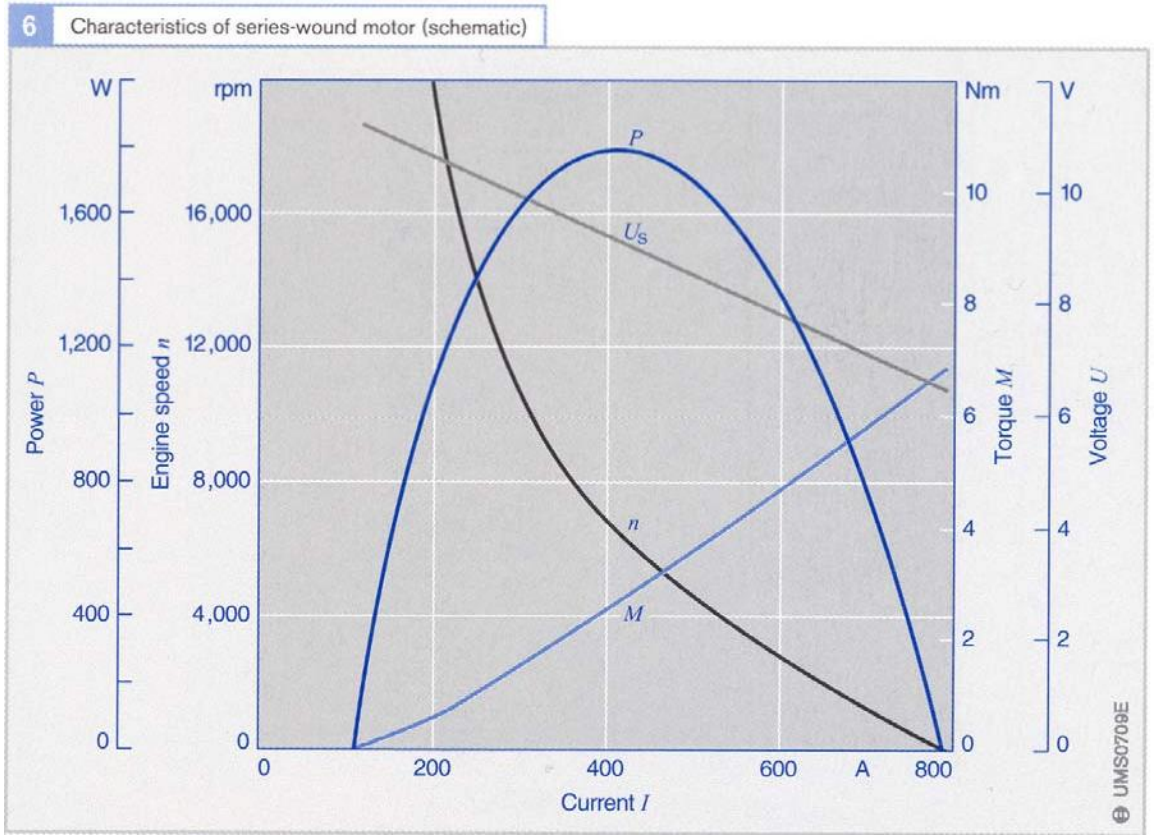


Fig. 5

1 Pole shoes
2 Excitation winding
3 Stator housing



$$B = c_3 \cdot I$$

$$M = c_1 \cdot c_3 \cdot l_{Fe} \cdot d \cdot I^2$$

$$n = \frac{1}{2 \cdot \pi \cdot c_2 \cdot c_3 \cdot l_{Fe} \cdot d} \left[\frac{U_L - U_{br}}{I} - (R_i + R_{perm} + R_S) \right]$$

ЕЛЕКТРИЧНЕ МАШИНЕ НА ВОЗИЛИМА

Побуда од сталних магнета и са магнетно-проводним умецима

8 Stator housing with permanent magnets and flux concentrators

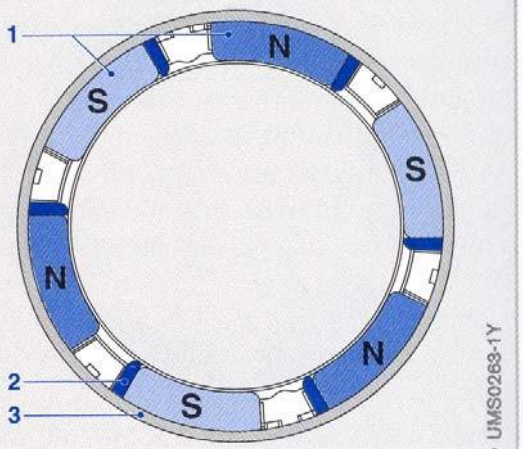
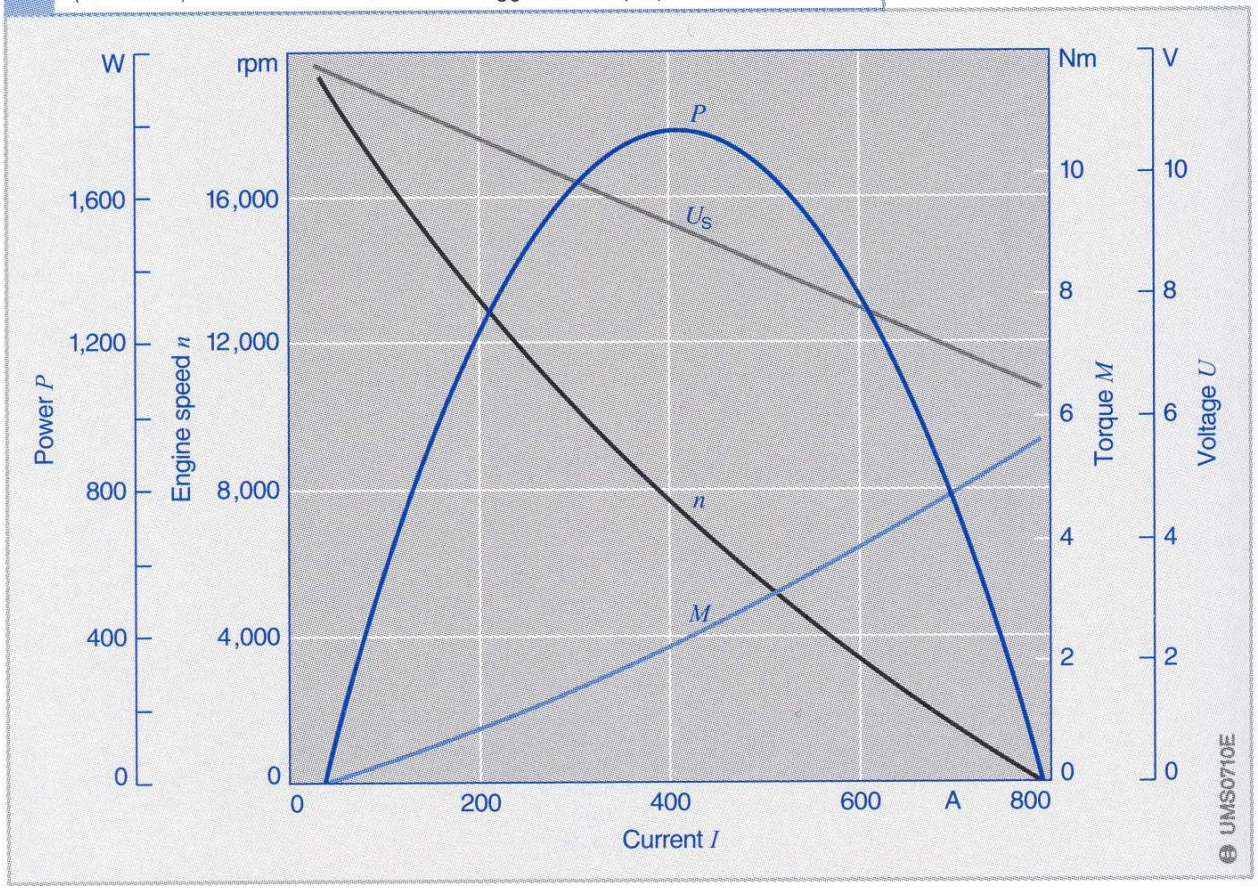


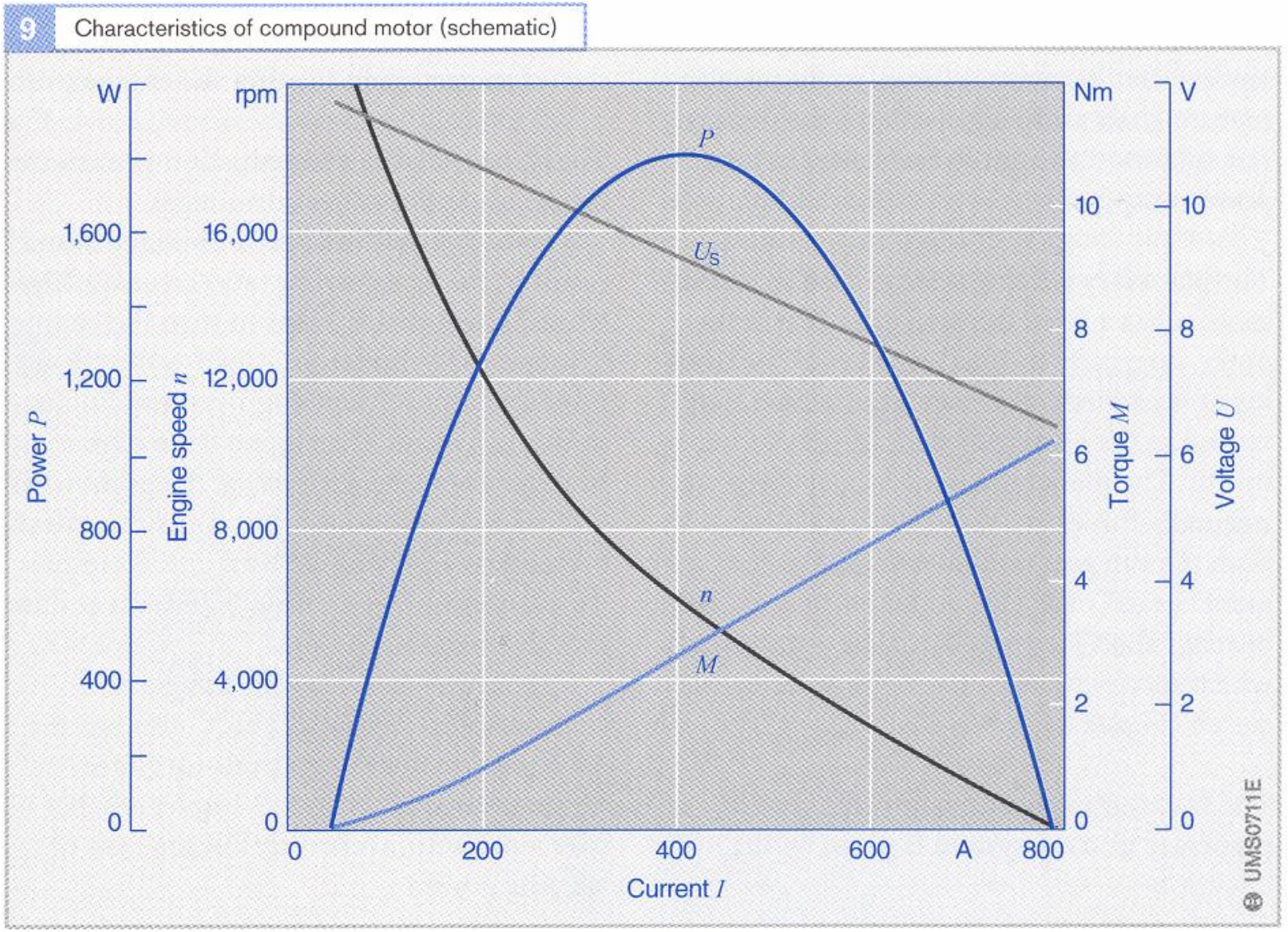
Fig. 8

1 Permanent magnets
2 Flux concentrators
3 Stator housing

7 Characteristics of permanent-magnet motor with flux concentrators (schematic, effect of flux concentrators exaggerated for purposes of illustration)



Мешовита побуда



ДИРЕКТНИ СТАРТЕРИ И СА МЕЂУПРЕНОСНИКОМ

10 Principle of planetary gear

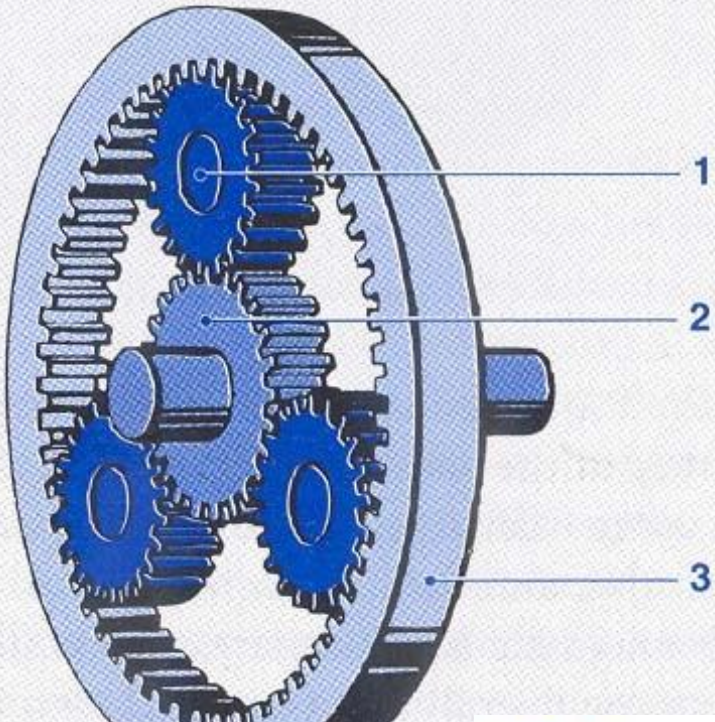


Fig. 10

1 Planet gear
2 Sun gear
3 Internal gear

11 Starter-motor reduction gear

$$i = 1 + \frac{\text{Number of teeth on internal gear}}{\text{Number of teeth on sun gear}}$$

ЕЛЕКТРИЧНЕ МАШИНЕ НА ВОЗИЛИМА

АУТОМАТ СТАРТЕРА

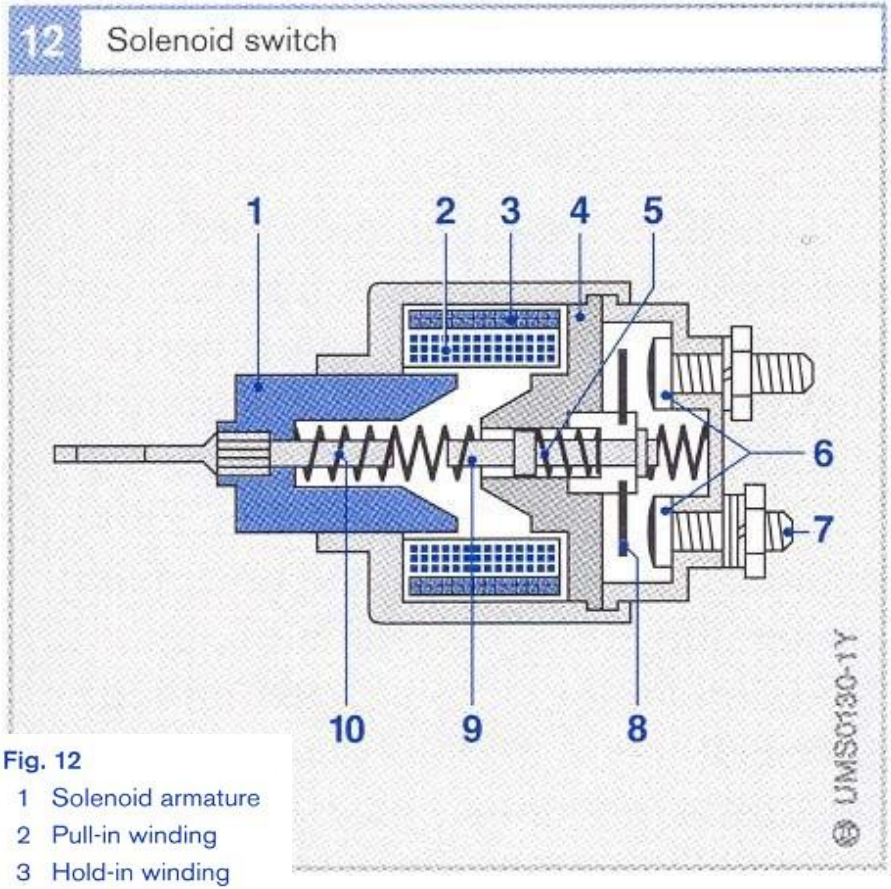


Fig. 12
1 Solenoid armature
2 Pull-in winding
3 Hold-in winding
4 Solenoid core
5 Contact spring
6 Switch contacts
7 Electrical connection
8 Switch contact
9 Armature shaft (split)
10 Return spring

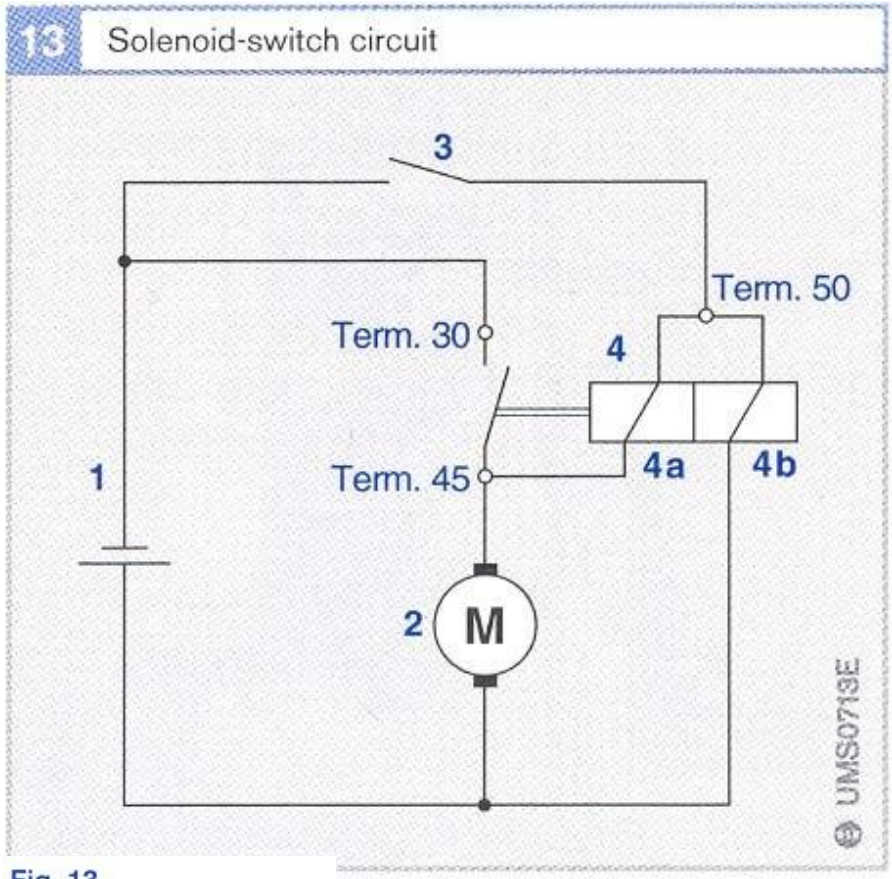


Fig. 13
1 Battery
2 Starter motor
3 Ignition/starter switch
4 Solenoid switch
4a Pull-in winding
4b Hold-in winding

Заштита котве релеја

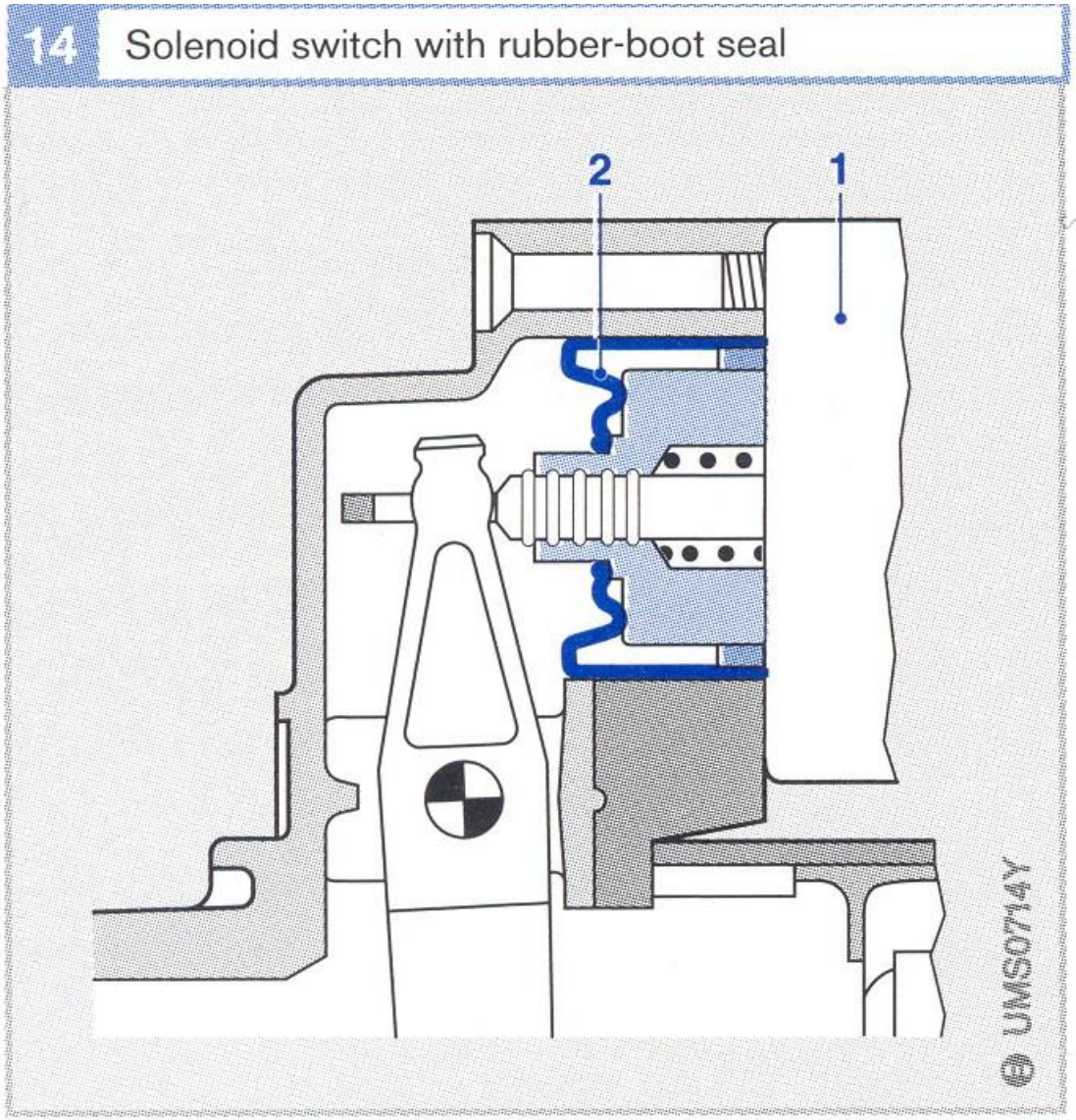


Fig. 14

1 Solenoid switch

2 Rubber boot

СПОЈНИЦЕ СА МЕХАНИЗМОМ ЗА ПРОКЛИЗАВАЊЕ

Спојница са ролерима

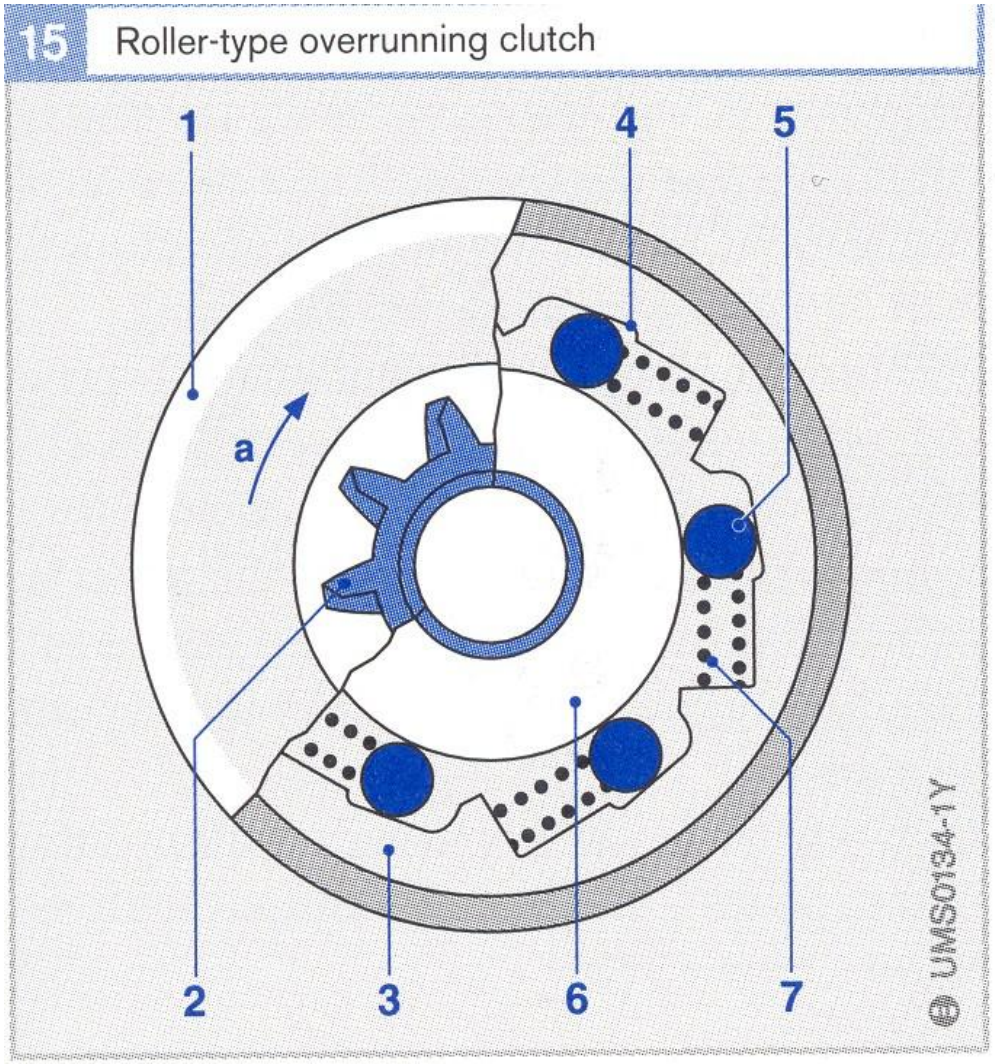
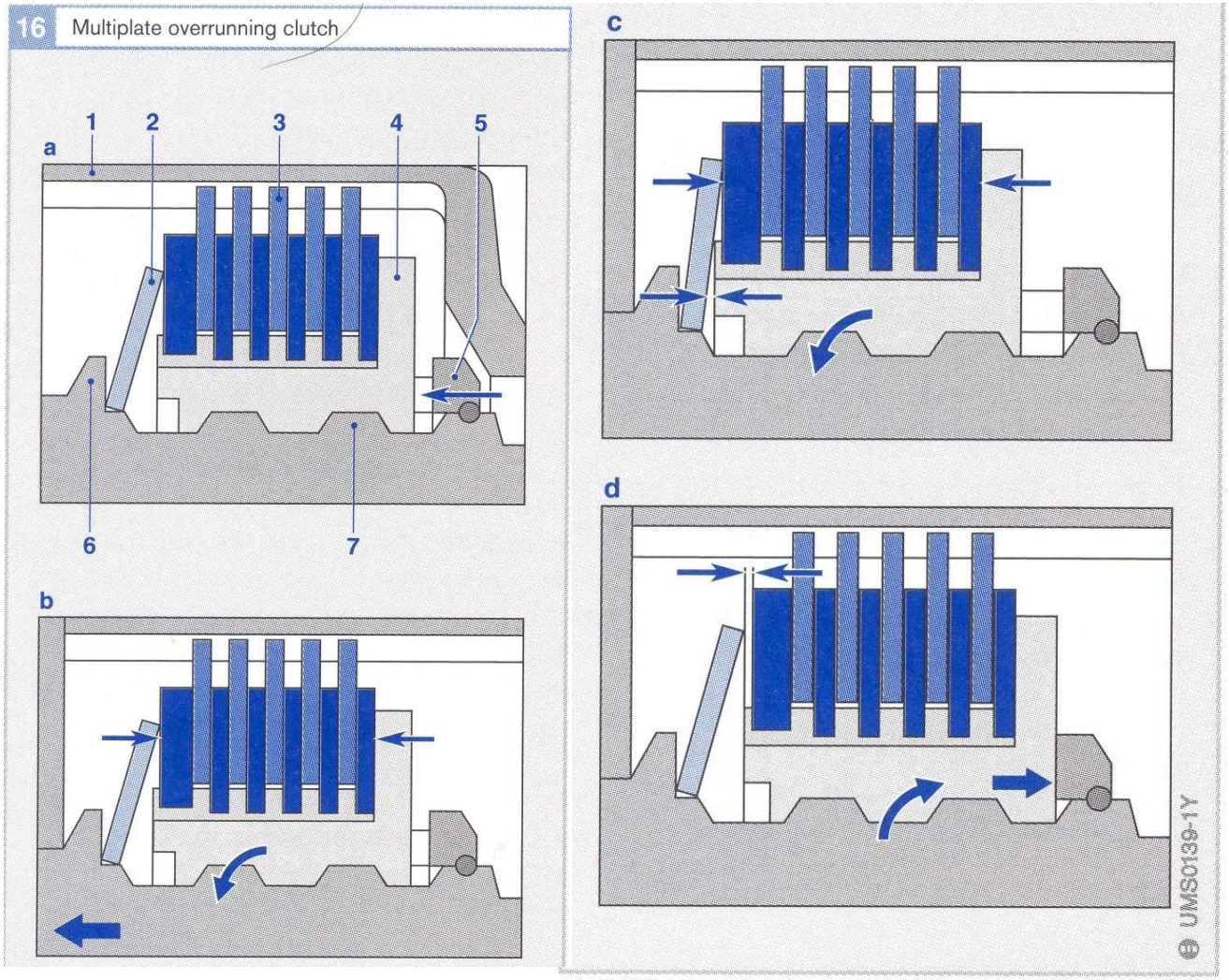


Fig. 15

1 Cap
2 Pinion
3 Driver and clutch shell
4 Roller race
5 Cylindrical roller
6 Pinion shaft
7 Springs

a Direction of rotation

Спојница са ламелама



Explanation of Figure 16:

a Resting position

Disc spring compresses laminated core with initial force.

Transmission of drive to clutch race ensured by frictional effect.

b Transmission of drive

Pinion engaged.

Clutch race presses against disc spring.

Compression increases.

Laminated core fully locked.

c Torque limitation

Clutch race presses disc spring against collar.

Forces in equilibrium at design rating.

Plates slip if design rating exceeded.

d Overrunning

Direction of force transmission reversed.

Clutch race runs up against stop ring, thus relieving plate pressure/disengaging drive.

Fig. 16

1 Driver flange
2 Disc spring
3 Laminated core
4 Clutch race
5 Stop ring
6 Stop collar on output shaft
7 Helical spline on output shaft

Спојница са чеоним зупцима

17 Radial-tooth overrunning clutch (resting position)

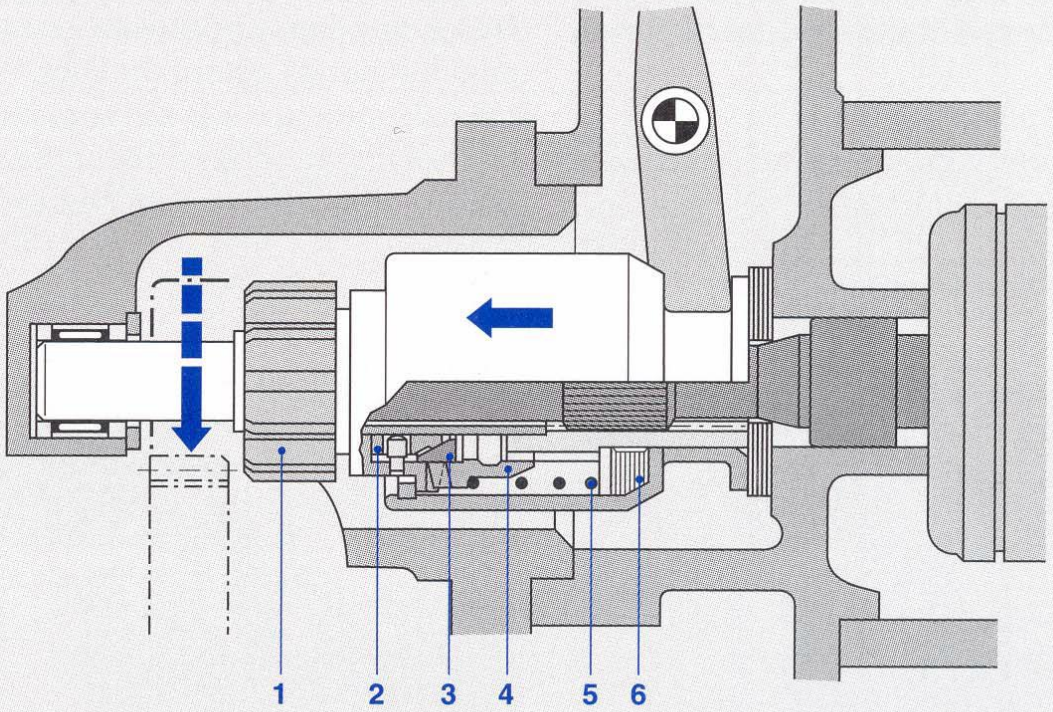


Fig. 17

1 Pinion
2 Flyweights
3 Internally tapered thrust ring
4 Clutch race with spur gearing
5 Spring
6 Rubber bumper